What are orthometric heights?

An orthometric height is the distance[7] (H) along the line of gravitational force, above or below the geoid (NAVD 88) to the Earth's surface or a bench mark. Orthometric heights are what is typically used for our civil works projects. An ellipsoid height[4] is the distance above or below the ellipsoid[6] and is typically a product of GPS measurements.

How do GPS determined elevations fit into this picture?

GPS positions[4] (elevations) are relative to the ellipsoid[6] and are termed ellipsoid heights whereas elevations[7] determined using conventional leveling methods are referenced the geoid[5]. To transform GPS determined elevations to other coordinate systems, at least one point in the survey must have known coordinates and datum in the desired system. Although hand-held CA code GPS receivers report elevations, these elevations are not sufficiently accurate for survey purposes. Carrier-phase based differential GPS elevations may be sufficiently accurate provided at least one bench mark[9] of known elevation is included in the survey.

What's Wrong With Using NGVD29 for Everything?

During the early part of the twentieth century it was assumed that global sea level was everywhere the same. In 1929 a general adjustment of bench marks was conducted to obtain a best fit of mean sea level observations at 26 tide stations in the United States and Canada. It was subsequently discovered that global mean sea level is not the same throughout the oceans i.e. its relationship to the geoid changes with respect to location. Moreover, the national bench mark network has been extensively expanded subsequent to 1929 and both subsidence and isostatic rebound have occurred in the continental US. The result is, that based upon the North American adjustment of 1988[5] (NAVD88), the Atlantic coastline is about 30cm below NGVD29[11] and the Rocky Mountains and westward to the Pacific coast is about 100cm higher than NGVD29. Use of NGVD29 would result in gross elevation errors everywhere except perhaps locations in the central Mississippi Valley.

Additional Information

National Datum and Subsidence Program:
www.agc.army.mil/ndsp/

Actions for Change:
https://maps.crrel.usace.army.mil/AFC/

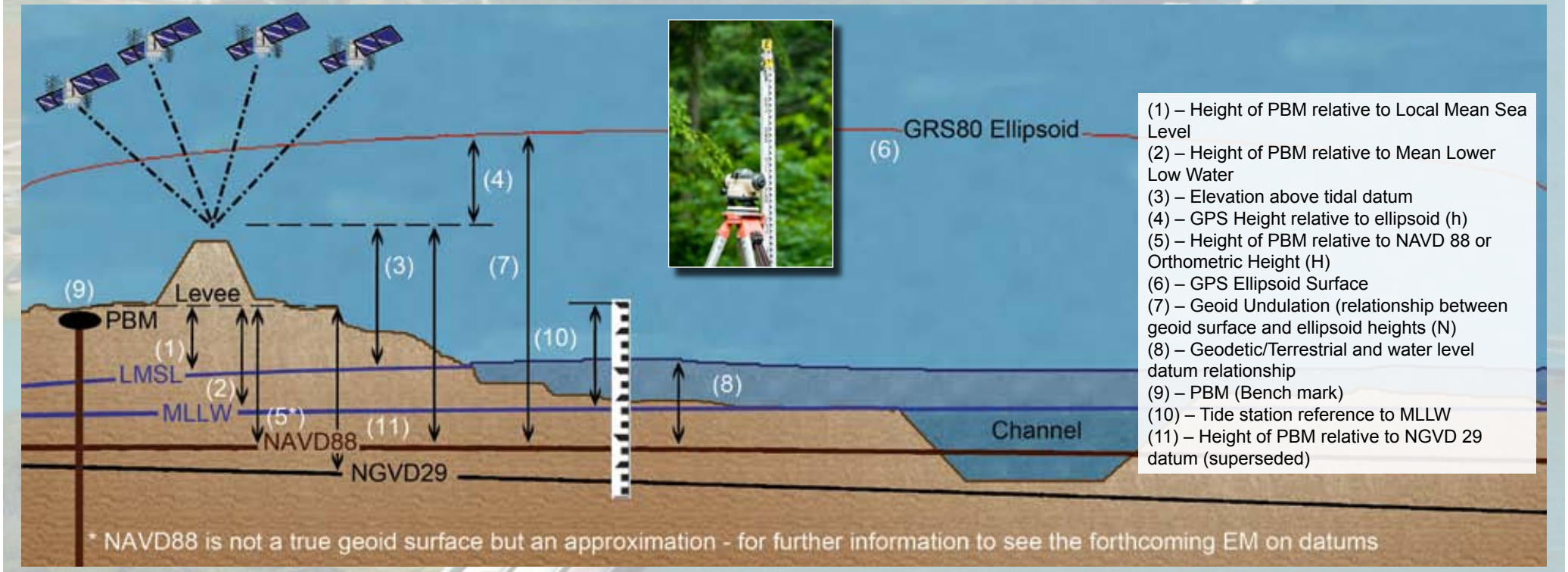
National Geodetic Survey:
http://ngs.noaa.gov

Center for Operational Oceanographic Products and Services: http://tidesandcurrents.noaa.gov/index.shtml

POC: mark.w.huber@usace.army.mil or
james.k.garster@usace.army.mil

US Army Corps of Engineers

Vertical Control Datums



(1) – Height of PBM relative to Local Mean Sea Level
(2) – Height of PBM relative to Mean Lower Low Water
(3) – Elevation above tidal datum
(4) – GPS Height relative to ellipsoid (h)
(5) – Height of PBM relative to NAVD 88 or Orthometric Height (H)
(6) – GPS Ellipsoid Surface
(7) – Geoid Undulation (relationship between geoid surface and ellipsoid heights (N)
(8) – Geodetic/Terrestrial and water level datum relationship
(9) – PBM (Bench mark)
(10) – Tide station reference to MLLW
(11) – Height of PBM relative to NGVD 29 datum (superseded)

What is a vertical datum?

A vertical datum is a reference surface, e.g., an Earth model ellipsoid[6], the geoid, or Local Mean Sea Level[1] (LMSL) to which heights are referenced. It is termed a tidal datum when defined by a particular phase of the tide, e,g, Mean Lower Low Water[2] (MLLW). In order that tidal datums may be recovered when needed, such as a tide station[10] being damaged or destroyed by a storm, these datums are referenced to fixed terrestrial points such as bench marks[9].

What's a Tidal Datum?

A tidal datum is an elevation defined by a particular phase of the tide. Examples of tidal datums are Mean High Water (MHW), Mean Tide Level (MTL), Mean Sea Level[1], and Mean Lower Low Water[2] (MLLW). Tidal datums are computed using observations acquired at a specific tide station and are valid at that particular station. A datum located in a water body is considered tidal if the variation in water level is sufficiently predictable based upon the phases of the moon and sun. Otherwise, it is considered a non-tidal (hydraulic) datum.

What's a Tidal Epoch?

Tidal variations can be considered as comprised of periodic and apparent secular trends. A specific 19-year period based upon the Metonic cycle is selected so that all tidal datum determinations will have a common reference period. This period is termed a tidal epoch. For tide stations located in the United States and its possessions, this period is called the National Tidal Datum Epoch (NTDE). The present NTDE is the period 1983 through 2001.

Why is it important to use a particular tidal epoch?

Tidal records typically contain the results of subsidence, post glacial rebound, and sea level rise in addition to the periodic variations caused by the sun and moon. Over time, the relative sea level rise can alter the relative elevation[8] between tidal[1] and related terrestrial[5] datums. When comparing elevations[3] which are based upon tidal datums, one should insure that common epochs are used in order to account for the effects of relative sea level rise. Moreover, relative sea level rise can cause changes in related tidal datums, such as MLLW and MHW

What is the geoid? What is the ellipsoid? Why do we need both reference systems?

The geoid[5] is an equipotential gravitational surface that is approximated by mean sea level and is everywhere perpendicular to the local direction of gravity. The geoid is affected by the distribution of the earth's mass and rotation, hence it is an irregular surface. The ellipsoid[6] is a mathematically defined surface obtained by revolving an ellipse around the earth's polar axis. The dimensions of the semi-major and semi-minor axes of the ellipse are chosen to give a good fit of the ellipsoid to the geoid over a large area, such as North America or Europe. Approximating the Earth's shape as an ellipsoid occurred as early as the nineteenth century. In current practice an important reason for both reference systems is that positions determined using the GPS[4] are relative to the ellipsoid and elevations determined by conventional leveling[7] are relative to the geoid.